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(54) DC-DC converter circuit, power supply selection circuit, and apparatus

(57) A DC-DC converter circuit (100) has a plurality of input terminals (IN1, IN2) connected to respective DC power supplies, and an output terminal (OUT). The DC-DC converter circuit comprises a power supply selection section (110) for selecting the lowest-voltage DC power supply among those not less than a predetermined voltage. A step-down type regulator section (10) converts the voltage of the selected DC power supply into a lower predetermined voltage, which is output through said output terminal (OUT).

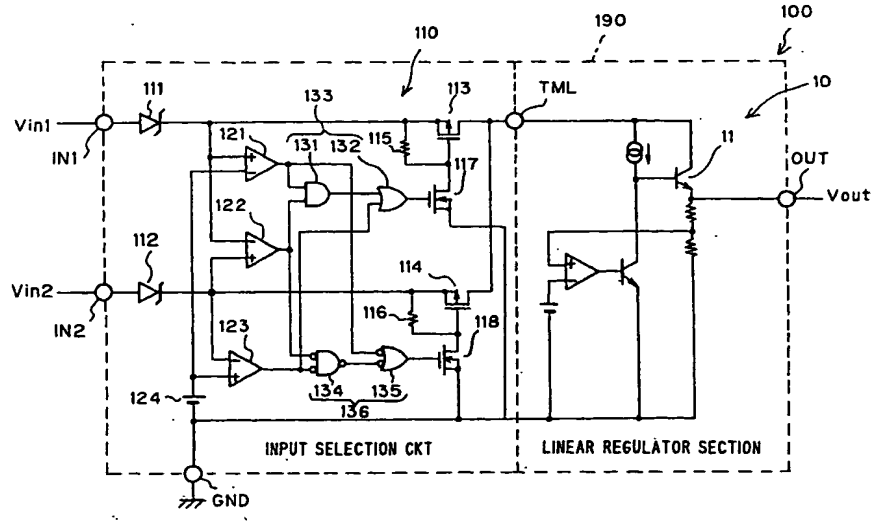

Fig.1

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Description

[0001] The present invention relates to a DC-DC converter circuit for converting a DC voltage to another DC voltage, a power supply selection circuit for selecting one of a plurality of power supplies, and an apparatus provided with such a DC-DC converter circuit.

[0002] Many portable type electronic apparatuses such as notebook personal computers and the like are so arranged that they are operative by electric power obtained from a commercial power supply (electricity supply) and a battery incorporated therein as well.

[0003] Usually, such an apparatus incorporates therein a circuit for selecting whether electric power obtained from a commercial power supply or electric power obtained from a battery is to be used for operation of the apparatus (for example, Japanese Patent Laid Open Gazette Hei.9-182288, and Japanese Patent Laid Open Gazette Hei.9-308102). According to such a type of circuit, when electric power obtained from the commercial power supply is supplied to the apparatus , this electric power takes precedence in use, and when it is detected that a supply of power from the commercial power supply is stopped, the supply of power is changed over to a supply of power from the battery. As another type of the power supply switching circuit, there is also known a power supply switching circuit arranged in such a manner that in view of the fact that electric power obtained from the commercial power supply is generally higher in voltage than the battery, the supply of power is performed from the source having the highest voltage.

[0004] Generally, the voltage of a battery is gradually lowered, as the discharge of the battery advances. Thus, an apparatus is provided with a DC-DC converter circuit for maintaining the voltage of the electric power to be used in the apparatus .

[0005] Fig. 7 is a circuit diagram showing a first example of a linear regulator. The linear regulator is a sort of a DC-DC converter circuit and is generally widely used.

[0006] A linear regulator section 10 is provided on an LSI having an input terminal IN through which electric power of an input voltage Vin is applied. The linear regulator section 10 converts the electric power of the input voltage Vin to an output voltage Vout (Vin > Vout) which is lower than the input voltage Vin, and outputs the electric power of the output voltage Vout through an output terminal OUT.

[0007] Between the input terminal IN and the output terminal OUT, an NPN transistor 11 for output voltage control is disposed, and between the input terminal IN and a base of the NPN transistor 11, a constant current source 12 is disposed. A current outputted from the constant current source 12 conducts through the base of the NPN transistor 11 in the form of a base current thereof, and further conducts through a collector of an additional NPN transistor 13 in the form of a collector current thereof. An emitter of the NPN transistor 13 is connected to a ground terminal GND which is grounded. The output voltage Vout of the output terminal OUT is fed to a positive input terminal of a differential amplifier 16 through a potential divider formed by two resistances 14 and 15, while a reference voltage generated by a reference voltage source 17 is fed to a negative input terminal of the differential amplifier 16. An output terminal of the differential amplifier 16 is connected to a base of the NPN transistor 13.

[0008] In the event that the output voltage Vout of the output terminal OUT is higher than a predetermined reference output voltage, an output voltage of the differential amplifier 16 is increased, so that a collector current of the NPN transistor 13 is increased. That is, of the current outputted from the constant current source 12, current used as the collector current of the NPN transistor 13 is increased, and as a result, the base current of the NPN transistor 11 for output voltage control is reduced and thereby the output voltage Vout of the output terminal OUT is lowered.

[0009] On the other hand, in the event that the output voltage Vout of the output terminal OUT is biased with a voltage lower than a predetermined reference output voltage, an output voltage of the differential amplifier 16 is lowered, so that the collector current of the NPN transistor 13 is decreased. That is, the base current of the NPN transistor 11 is increased and thereby the output voltage Vout of the output terminal OUT is increased.

[0010] In this manner, electric power of a constant output voltage Vout is outputted from the output terminal OUT.

[0011] Fig. 8 is a circuit diagram showing a second example of a linear regulator. This differs from the circuit of Fig. 7 as follows.

[0012] A linear regulator 10' shown in Fig. 8 is provided with a PNP transistor 18 for output voltage control, instead of the NPN transistor 11 for output voltage control in the linear regulator 10 shown in Fig. 7. As a result, the output voltage Vout of the output terminal OUT is fed to the negative input terminal of the differential amplifier 16 through a potential divider formed by the two resistances 14 and 15, while the reference voltage generated by the reference voltage source 17 is fed to the positive input terminal of the differential amplifier 16.

[0013] In the event that the output terminal OUT is biased with a voltage Vout higher than a predetermined reference output voltage, the output voltage of the differential amplifier 16 is lowered, so that the collector current of the NPN transistor 13 is decreased. That is, of the current outputted from the constant current source 12, current used as the collector current of the NPN transistor 13 is decreased, and as a result, the base current of the PNP transistor 18 is reduced and thereby the output voltage Vout of the output terminal OUT is lowered.

[0014] On the other hand, if Vout becomes lower than the predetermined reference output voltage, the output voltage of the differential amplifier 16 goes up, so that the collector current of the NPN transistor 13 is in-

creased. That is, the base current of the PNP transistor 18 is increased and thereby the output voltage Vout of the output terminal OUT is increased (restored).

[0015] In this manner, electric power of a constant output voltage Vout is outputted from the output terminal OUT.

[0016] Fig. 9 is a circuit diagram showing a third example of a linear regulator.

[0017] A main difference from the second example of the linear regulator shown in Fig. 8 is that the PNP transistor 18 is replaced by a P channel MOSFET transistor 19.

[0018] The circuit operation is the same as that of the second example shown in Fig. 8, and thus the explanation of the third example will be omitted.

[0019] Fig. 10 is a circuit diagram showing an example of a switching regulator. The switching regulator 20 is also a sort of DC-DC converter circuit and is generally widely used.

[0020] Electric power of voltage Vin is fed through an input terminal IN of the switching regulator, and electric power of output voltage Vout (here dealing with a step-down type and thus Vin > Vout) is outputted from a second output terminal OUT 2, of first and second output terminals OUT 1 and OUT 2. Between the first and second output terminals OUT 1 and OUT 2, an external coil 31 is connected. Between the second output terminals OUT 2 and the ground, an external capacitance 32 is connected.

[0021] Portions excepting the external coil 31 and the external capacitance 32, of the switching regulator 20 are incorporated in an LSI (Large Scale Integrated Circuit).

[0022] Between the input terminal IN and the output terminal OUT 1,a P channel MOS transistor 21 is disposed. An output of a PWM comparator 26 is connected to a gate of the P channel MOS transistor 21. An output of a differential amplifier 24 and an output of a triangle wave generator 27 are fed to the PWM comparator 26. The PWM comparator 26 will be described later.

[0023] The voltage Vout of the second output terminal OUT2 is fed to a negative input terminal of the differential amplifier 24 through a potential divider formed by two resistances 22 and 23, while a reference voltage generated by a reference voltage source 25 is fed to a positive input terminal of the differential amplifier 24. Between the first output terminal OUT 1 and a ground terminal GND which is grounded, a diode 28 is connected. The cathode of the diode 28 is connected to the first output terminal OUT 1, and the anode of the diode 28 is connected to the ground terminal GND.

[0024] The PWM comparator 26 compares an output voltage of the differential amplifier 24 with a triangle wave signal outputted from the triangle wave generator 27. When the output voltage of the differential amplifier 24 is lower in voltage than the triangle wave signal, the PWM comparator 26 generates a pulse signal of 'H' level. When the output voltage of the differential amplifier 24 is higher in voltage than the triangle wave signal, the PWM comparator 26 generates a pulse signal of 'L' level. Such a pulse signal is fed to the gate of the MOS transistor 21, so that the MOS transistor 21 turns on or off in accordance with a variation between 'H' level and 'L' level of the pulse signal. That is, the MOS transistor 21 switches the input voltage Vin at the same repetitive frequency as that of the triangle wave signal.

[0025] The diode 28, the coil 31 and the capacitance 32 smoothes the input voltage Vin after the switching and generates the output voltage Vout.

[0026] When the output voltage Vout slightly exceeds a preset voltage, the output voltage of the differential amplifier 24 goes down, so that a pulse width (a pulse width of the 'L' level) of the pulse signal generated by the PWM comparator 26 is narrowed slightly and whereby the output voltage Vout goes down. On the other hand, when the output voltage Vout goes down, the output voltage of the differential amplifier 24 goes up, so that a pulse width (a pulse width of the 'L' level) of the pulse signal generated by the PWM comparator 26 is expanded, whereby the output voltage Vout goes up. Thus, the switching regulator 20 controls the electric power to he outputted at a constant voltage Vout.

[0027] In an electronic apparatus , for example, a personal computer, it is frequently the case that a plurality of circuit units, which are operative with mutually different DC voltages, exist in the apparatus . Such an apparatus is provided with a plurality of DC-DC converter circuits which output electric power of individual voltages, respectively. Disadvantages of DC-DC converter circuits are that a great deal of electric power is consumed for conversion of DC voltages. Therefore, power is wasted, the consumption of battery power is hastened, and the temperature of the apparatus rises. For example, in case of the DC-DC converter circuit of the linear regulator scheme shown in Figs. 7 to 9, for conversion from the input voltage of 16 volts into the output voltage of 3.3 volts, the conversion efficiency is 20%, and the remaining 80% is a power loss. Particularly, in an apparatus in which a plurality of mutually different DC voltages are used and a plurality of DC-DC converter circuits are needed in order to generate the plurality of mutually different DC voltages, there exists a requirement to improve the conversion efficiency in the DC-DC converter circuits.

[0028] In view of the foregoing, it is a consideration of the present invention to provide a DC-DC converter circuit improved in conversion efficiency, a power supply selection circuit in which an existing DC-DC converter circuit is used to perform a voltage conversion improved in conversion efficiency, and an apparatus incorporating such a DC-DC converter circuit improved in conversion efficiency.

[0029] According to a first aspect of the present invention there is provided a DC-DC converter circuit having a plurality of input terminals each for connection to one of a plurality of DC power supplies, and an output ter-

minal, said first DC-DC converter circuit comprising:

a power supply selection section for selecting a DC power supply of lowest voltage on condition that the voltage is not less than a predetermined voltage; and

a step-down type of regulator section for converting the voltage of the DC power supply selected by said power supply selection section into a predetermined voltage lower than the voltage of the DC power supply selected by said power supply selection section, and outputting the converted voltage through said output terminal.

[0030] As mentioned above, in case of the DC-DC converter circuit according to the linear regulator scheme, the conversion efficiency is 20% for a conversion of 16V to 3.3V. On the other hand, however, in a case where a power supply of 5V exists, the conversion efficiency is 66% for the same conversion. In this manner, when an output voltage is obtained from an input voltage which is as close to the output voltage as possible, it is possible to greatly improve the conversion efficiency. This is applicable also to the switching regulator scheme as well as the linear regulator scheme.

[0031] The first aspect DC-DC converter circuit according to the present invention utilizes this principle as mentioned above.

[0032] That is, the power supply selection section selects a DC power supply of the lowest voltage from among a plurality of DC power supplies, and inputs the selected input voltage to the regulator section. However, in this case, in order to avoid selecting an input power supply of 0v, for example when a power supply is not operative or not connected, there is provided a condition that the lowest voltage is not less than a predetermined voltage. The regulator section converts the voltage of the DC power supply thus selected to a DC voltage lower than the voltage of the selected DC power supply. Thus, it is possible to implement a high efficiency of voltage conversion wherein the optimum power supply is selected in accordance with the situation of the power supply.

[0033] According to a second aspect of the present invention there is provided a DC-DC converter circuit having a first input terminal connected to a predetermined first DC power supply, and a second input terminal connected to a predetermined second DC power supply which has a voltage lower than a voltage of said first DC power supply, and an output terminal, said DC-DC converter circuit comprising:

a power supply selection section for selecting the first DC power supply connected to said first input terminal and the second DC power supply connected-to said second input terminal according to whether the voltage of the second DC power supply is less than a predetermined voltage or is not less than the predetermined voltage, respectively; and

a step-down type of regulator section for converting the voltage of the DC power supply selected by said power supply selection section into a predetermined voltage lower than the voltage of the DC power supply selected by said power supply selection section, and outputting the converted voltage through said output terminal.

[0034] In the event that it is decided that as compared with the voltage of the first DC power supply entered through the first input terminal, the voltage of the second DC power supply entered through the second input terminal is lower, or it is arranged that the second input terminal is connected to a DC power supply (second DC PSU) having a lower voltage, it is possible to simplify the power supply selection section in structure taking into account the idea of the first aspect DC-DC converter circuit of the present invention.

[0035] In the DC-DC converter circuits according to the first and second aspects of the present invention, said regulator section may comprise a linear regulator. In this case, it is preferable that said power supply selection section and said regulator section comprising the linear regulator are arranged in an integrated circuit. Or alternatively, it is preferable that said power supply selection circuit and portions of said regulator section comprising the linear regulator, are arranged in an integrated circuit (IC), with the exception of an output voltage control transistor which is located outside the IC.

[0036] In the DC-DC converter circuits according to the first and second aspects of the present invention, said regulator section may comprise a switching regulator. In this case, it is preferable that said power supply selection section and portions of said regulator section comprising the switching regulator are arranged in an IC, with the exception of a voltage smoothing circuit portion which is located outside the IC.

[0037] Arrangement in an integrated circuit enables a more stable operation, lowers cost and saves space.

[0038] According to a third aspect of the present invention there is provided a power supply selection circuit comprising:

a plurality of input terminals connected to a plurality of DC power supplies;

a power supply selection section for selecting a DC power supply of lowest voltage, on condition that the voltage is not less than a predetermined voltage, from among the plurality of DC power supplies; and

an output terminal for outputting the voltage of the DC power supply selected by said power supply selection section.

[0039] According to a fourth aspect of the present invention there is provided a power supply selection circuit comprising:

a first input terminal connected to a predetermined first DC power supply;
a second input terminal connected to a predetermined second DC power supply which has a voltage lower than a voltage of said first DC power supply;
a power supply selection section for selecting the first DC power supply connected to said first input terminal and the second DC power supply connected to said second input terminal according to whether the voltage of the second DC power supply is less than a predetermined voltage or is not less than the predetermined voltage, respectively; and
an output terminal for outputting the voltage of the DC power supply selected by said power supply selection section.

[0040] The third and fourth aspect power supply selection circuits correspond to the power supply selection sections of the first and second aspect DC-DC converter circuits, respectively. The DC-DC converter circuits corresponding to the regulator sections of the first and second aspect DC-DC converter circuits can be connected to the later stages of the third and fourth power supply selection circuits, respectively. This feature makes it possible to perform a highly efficient DC-DC conversion for the DC-DC converter circuits.

[0041] According to a fifth aspect of the present invention there is provided a DC-DC converter having a plurality of input terminals connected to respective DC power supplies, and an output terminal, said DC-DC converter circuit comprising: a power supply selection section for selecting the lowest-voltage DC power supply among those of said DC power supplies not less than a predetermined voltage; and a step-down type regulator section for converting the voltage of the selected DC power supply into a lower predetermined voltage, and outputting the lower predetermined voltage through said output terminal.

[0042] The apparatus of the present invention as mentioned above is provided with first and second DC-DC converters. The second DC-DC converter, which outputs the lower DC voltage, is arranged with the DC-DC converter circuit of the first or second aspect. This feature makes it possible to perform an efficient DC-DC conversion, reduce power consumption and suppress temperature rise of the apparatus.

[0043] Generally power supply systems are wired within apparatuses beforehand, and therefore it will be usual for the DC-DC converter circuit of the second aspect of the present invention to be used as the second DC-DC converter. However, the DC-DC converter circuit of the first aspect of the present invention may be used as the second DC-DC converter. In this case, the power supply selection section of the second DC-DC converter serves to block both the path for transmitting the output of the first DC-DC converter to the regulator section and the path for transmitting the voltage of the first DC power supply to the regulator section, when the first DC power supply is less than a predetermined voltage, in the event that the output of the first DC-DC converter is less than a predetermined voltage.

[0044] A detailed description of embodiments of the present invention will now be given, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a circuit diagram of a first embodiment of a DC-DC converter circuit according to the present invention, including a first embodiment of a power supply selection circuit according to the present invention;
Fig. 2 is a circuit diagram of a second embodiment of a DC-DC converter circuit according to the present invention, including a second embodiment of a power supply selection circuit according to the present invention;
Fig. 3 is a circuit diagram of a third embodiment of a DC-DC converter circuit according to the present invention;
Fig. 4 is a circuit diagram of a fourth embodiment of a DC-DC converter circuit according to the present invention;
Fig. 5 is a circuit diagram of a fifth embodiment of a DC-DC converter circuit according to the present invention;
Fig. 6 is a block diagram showing an embodiment of an apparatus according to the present invention;
Fig. 7 is a circuit diagram showing a first example of a linear regulator;
Fig. 8 is a circuit diagram showing a second example of a linear regulator;
Fig. 9 is a circuit diagram showing a third example of a linear regulator; and

[0045] Fig. 10 is a circuit diagram showing an example of a switching regulator.

[0046] Fig. 1 is a circuit diagram of a first embodiment of a DC-DC converter circuit according to the present invention, including a first embodiment of a power supply selection circuit according to the present invention.

[0047] A DC-DC converter circuit 100 shown in Fig. 1 comprises an input selection circuit 110 and a linear regulator 10. The DC-DC converter circuit 100 is incorporated into an LSI chip 190 in its entirety. The input selection circuit 110 is an embodiment of a power supply selection circuit of the present invention.

[0048] The input selection circuit 110 is provided with two input terminals IN1 and IN2 to which DC supplies are connected, respectively. Input voltages Vin1 and Vin2 are applied through the input terminals IN1 and IN2, respectively.

[0049] The input selection circuit 110, between the input terminals (IN1 and IN2) and node TML, can be separated from the linear regulator section 10 (for example by incorporating the input selection circuit 110 into an LSI). In this case, the node TML is an output terminal of the input selection circuit 110 and transfers signals from

the input selection circuit 110 to the linear regulator section 10, the anodes of the diodes 111 and 112 are connected to the input terminals IN1 and IN2, respectively, and the inputs of P channel transistors 113 and 114 are connected to the cathodes of the diodes 111 and 112, respectively. Input sides of the P channel MOS transistors 113 and 114 are also connected via resistances 115 and 116 to their gates, respectively. Between the gates of the P channel MOS transistors 113 and 114 and a ground terminal GND, N channel MOS transistors 117 and 118 are disposed, respectively. The ground terminal GND is grounded.

[0050] The input selection circuit 110 is further provided with first, second and third comparators 121, 122 and 123, and a reference voltage source 124. A positive input terminal of the first comparator 121 is connected to a cathode of the diode 111, and a negative input terminal of the first comparator 121 is connected to the reference voltage source 124. A positive input terminal of the second comparator 122 is connected to a cathode of the diode 112, and a negative input terminal of the second comparator 122 is connected to the cathode of the diode 111. A positive input terminal of the third comparator 123 is connected to the reference voltage source 124, and a negative input terminal of the third comparator 123 is connected to the cathode of the diode 112.

[0051] Outputs of the three comparators 121, 122 and 123 are transmitted via a first logical circuit 133 comprising an AND gate 131 and an OR gate 132 to the N channel MOS transistor 117, and further transmitted via a second logical circuit 136 comprising an OR gate 134 and a NAND gate 135 to another N channel MOS transistor 118.

[0052] The first comparator 121 compares voltage Vin1 of the first input terminal IN1 with the voltage of the reference voltage source 124, and determines as to whether the voltage Vin1 of the first input terminal IN1 is higher than the voltage of the reference voltage source 124. In other words, it is determined as to whether the reference voltage source 124 is connected to the first input terminal IN1.

[0053] In a similar fashion to that of the first comparator 121, the third comparator 123 compares voltage Vin2 of the second input terminal IN2 with the voltage of the reference voltage source 124, and determines as to whether the voltage Vin2 of the second input terminal IN2 is higher than the voltage of the reference voltage source 124. In other words, it is determined as to whether the reference voltage source 124 is surely connected to the second input terminal IN2.

[0054] The second comparator 122 is different from the first comparator 121 and the third comparator 123, and compares the voltage Vin1 of the first input terminal IN1 with the voltage Vin2 of the second input terminal IN2.

[0055] When the voltage Vin1 of the first input terminal IN1 exceeds the reference voltage and Vin1 < Vin2, the first logical circuit 133 generates an 'H' level signal, so that the NMOS transistor 117 conducts and whereby the gate of the PMOS transistor 113 goes down to the potential of the ground side. Thus,the PMOS transistor 113 turns on, so that the voltage Vin1 of the first input terminal IN1 is transmitted via the node TML to the linear regulator section 10. At that time, the output (the gate of the NMOS transistor 118) of the second logical circuit 136 outputs an 'L' level signal, so that the NMOS transistor 118 turns off. Thus the PMOS transistor 114 also turns off, so that the voltage Vin2 of the second input terminal IN2 is not transmitted to the linear regulator section 10.

[0056] For example, it is assumed that Vin1 = 5.0V, Vin2 = 16.0V. In the event that the linear regulator section 10 outputs voltage of 3.3V, the input selection circuit 110 selects Vin1 = 5.0V. Thus, the efficiency of the linear regulator section 10 is 66%.

[0057] On the other hand, in case of Vin2 < Vin1, on the condition that Vin2 exceeds the reference voltage, the output of the first logical circuit 133 outputs an 'L' level, and the second logical circuit 136 generates a 'H' level. Thus, the NMOS transistor 117 and the PMOS transistor 113 turn off, so that transfer of Vin1 to the linear regulator section 10 is inhibited, and the NMOS transistor 118 and the PMOS transistor 114 turn on, so that Vin2 is transferred to the linear regulator section 10. In this case, for example, assuming that Vin1 = 16.0V, Vin2 = 5.0V and the linear regulator section 10 outputs voltage of 3.3V, the input selection circuit 110 selects Vin2 = 5.0V. Thus, the efficiency of the linear regulator section 10 is 66%.

[0058] In the event that Vin2 is less than the reference voltage (typically the input terminal IN2 is disconnected from the source), while Vin1 is not less than the reference voltage, the first, second and third comparators 121, 122 and 123 provide 'H' level, 'L' level, and 'H' level signals, respectively, so that the first logical circuit 133 generates an 'H' level signal, and the second logical circuit 136 generates an 'L' level signal. Thus, the NMOS transistor 117 conducts and the PMOS transistor 113 also conducts. On the other hand, the NMOS transistor 118 turns off and the PMOS transistor 114 also turns off. Consequently, in this case, the voltage Vin1 entered through the first input terminal IN1 is transmitted to the linear regulator section 10. In the event that the linear regulator section 10 outputs voltage of 3.3V, the efficiency of the linear regulator section 10 is 66% when Vin1 = 5.0V, and is 20% when Vin1 = 16.0V.

[0059] On the other hand, in the event that Vin1 is less than the reference voltage (typically the input terminal IN1 is disconnected from the source), while Vin2 is not less than the reference voltage, the first, second and third comparators 121, 122 and 123 provide 'L' level, 'H' level, and 'L' level signals, respectively, so that the first logical circuit 133 generates an 'L' level signal, and the second logical circuit 136 generates an 'H' level signal. Thus, the NMOS transistor 117 turns off and the PMOS transistor 113 also turns off. On the other hand, the

NMOS transistor 118 turns on and the PMOS transistor 114 also turns on. Consequently, in this case, the voltage Vin2 entered through the second input terminal IN2 is transmitted to the linear regulator section 10. In the event that the linear regulator section 10 outputs voltage of 3.3V, the efficiency of the linear regulator section 10 is 66%when Vin2 = 5.0V, and is 20% when Vin2 = 16.0V.

[0060] The linear regulator section 10 has the same structure as the linear regulator shown in Fig. 7, and generates, in accordance with the principle explained referring to Fig. 7, the stabilized output voltage Vout (Vout < Vin1, Vin2) lower than voltages Vin1 and Vin2 of the input terminals IN1 and IN2, for example, Vout = 3.3V, and outputs the same through the output terminal OUT.

[0061] In this manner, in the case of the DC-DC converter circuit 100 shown in Fig. 1, of two input voltages Vin1 and Vin2, the smaller one is transmitted to the linear regulator section 10 so as to be used for generating the output voltage Vout, on the condition that it is not less than the reference voltage. Thus, it is possible to perform the DC-DC conversion with excellent conversion efficiency.

[0062] Fig. 2 is a circuit diagram of a second embodiment of a DC-DC converter circuit according to the present invention, including a second embodiment of a power supply selection circuit according to the present invention.

[0063] A DC-DC converter circuit 200 shown in Fig. 2 comprises an input selection circuit 210 which is more simplified in structure as compared with the input selection circuit 110 according to the first embodiment shown in Fig. 1, and a linear regulator section 10 which has the same structure as the linear regulator section 10 according to the first embodiment shown in Fig. 1. In a similar fashion to that of the first embodiment shown in Fig. 1, the DC-DC converter circuit 200 is incorporated into an LSI chip 290 in its entirety.

[0064] The DC-DC converter circuit 200 is a circuit wherein it is intended to receive input voltages Vin1 and Vin2 through the input terminals IN1 and IN2, respectively, ensuring Vin1 > Vin2. Assurance of Vin1 > Vin2 may be implemented by means of, for example, differentiating types of connector, or fixedly wiring the respective connectors in an apparatus beforehand.

[0065] Between the first input terminal IN1 of the two input terminals IN1 and IN2 and a node TML coupling between the input selection circuit 210 and the linear regulator section 10, there are disposed a diode 211 of which an anode is connected to the input terminal IN1, and a PMOS transistor 213. Here, in the event that the input selection circuit (an example of the power supply selection circuit referred to in the present invention) is arranged in the form of a circuit separate from the linear regulator section 10 (for example, only the input selection circuit 210 is provided on one LSI chip), the node TML is an output terminal of the input selection circuit 210. The gate of the PMOS transistor 213 is connected via a resistance 215 to the diode 211. Between the gate of the PMOS transistor 213 and the ground terminal GND, an NMOS transistor 217 is disposed. The ground terminal GND is grounded.

[0066] Between another input terminal IN2 and the node TML, a diode 212 of which an anode is connected to the input terminal IN2 is disposed. A cathode of the diode 212 is connected to a negative input terminal of a comparator 221. A reference voltage source 224 is connected to a positive input terminal of the comparator 221. An output of the comparator 221 is connected to a gate of the NMOS transistor 217.

[0067] The comparator 221 compares the voltage Vin2 of the input terminal IN2 with a reference voltage obtained by the reference voltage source 224. This comparison is for a determination as to whether the reference voltage source 224 is surely connected to the second input terminal IN2.

[0068] When the voltage Vin2 is higher than the reference voltage, the output of the comparator 221 outputs an 'L' level, so that the NMOS transistor 217 turns off. Thus, the PMOS transistor 213 also turns off. As a result, the voltage Vin1 of the first input terminal IN1 is not transmitted to the linear regulator section 10, but the voltage Vin2 of the second input terminal IN2 is transmitted to the linear regulator section 10. On the other hand, in the event that the voltage Vin2 of the second input terminal IN2 generates a voltage (typically 0V) lower than the reference voltage, for example, when the source is not connected to the second input terminal IN2, or the source connected to the second input terminal IN2 is in a turn-off condition, the output of the comparator 221 generates an 'H' level, so that the NMOS transistor 217 turns on. Thus, the PMOS transistor 213 also turns on. As a result, the voltage Vin1 of the first input terminal IN1 is transmitted to the linear regulator section 10.

[0069] As mentioned above, the input selection circuit 210 shown in Fig. 2 is effective in the event that the condition of Vin1 > Vin2 is satisfied. When the voltage Vin2 is effective, the voltage Vin2 is transmitted to the linear regulator section 10. When the voltage Vin2 is not effective (e.g. 0V), the voltage Vin1 is transmitted to the linear regulator section 10.

[0070] The linear regulator section 10 is the same as the linear regulator section shown in Fig. 1 in structure, and generates the stabilized output voltage Vout lower than voltages Vin1 and Vin2 of the input terminals IN1 and IN2, and outputs the same through the output terminal OUT.

[0071] In this manner, also in case of the DC-DC converter circuit 200, when the voltage Vin2 of the voltages Vin1 and Vin2 (voltages Vin1 > Vin2) is effective, the voltage Vin2 is transmitted to the linear regulator section 10 to be used for generation of the output voltage Vout. Thus, it is possible to perform a DC-DC conversion excellent in conversion efficiency.

[0072] Fig. 3 is a circuit diagram of a third embodiment

of a DC-DC converter circuit according to the present invention. There will be described different points from the second embodiment shown in Fig. 2.

[0073] The difference between DC-DC converter circuit 300 (Fig. 3) and DC-DC converter circuit 200 of the second embodiment shown in Fig. 2 is that a portion excepting an NPN transistor 11 of the output voltage control section constituting the linear regulator section 10 is incorporated into an LSI chip 290 in the DC-DC converter 200, and the NPN transistor 11 is disposed outside an LSI chip 390 in the DC-DC converter 300. Thus, the LSI chip 390 needs two output terminals OUT1 and OUT2 in addition to an output terminal OUT3 corresponding to the output terminal OUT in the second embodiment shown in Fig. 2.

[0074] The operation of the circuit is the same as that of the second embodiment shown in Fig. 2, and thus its explanation will be omitted. The reason why the transistor 11 is disposed outside the LSI chip 390 is as follows. The DC-DC converter circuit 300 is of a large current capacity so that the secondary end thereof is permitted to consume a very large electric power, and thus as the transistor 11, there is a need to use a transistor which is capable of withstanding consumption of the large electric power. In view of the above-mentioned matter, a transistor of large capacity is needed as the transistor 11, and in addition, there is a need to perform a heat radiation by installing, for example, a heat sink and the like. That is, the transistor 11 is not suitable for incorporation into the LSI chip.

[0075] Thus, in a DC-DC converter circuit of a linear regulator scheme, a transistor for the output voltage control is mounted outside.

[0076] Fig. 4 is a circuit diagram of a fourth embodiment of a DC-DC converter circuit according to the present invention.

[0077] A DC-DC converter circuit 400 shown in Fig. 4 also comprises an input selection circuit 110, which is the first embodiment of the power supply selection circuit of the present invention also shown in Fig. 1, and a switching regulator section 20 which is the same as the switching regulator shown in Fig. 10. The circuit operation of the input selection circuit 110 and the switching regulator section 20 has been already explained, and thus its explanation will be omitted here. The DC-DC converter circuit 400 shown in Fig. 4 is incorporated into an LSI chip 490, except for a coil 31 and a capacitance 32, which are part of the switching regulator 20. The coil 31 and the capacitance 32 are considerably large and are not suitable for being incorporated into the LSI chip.

[0078] The input selection circuit 110 receives two input voltages Vin1 and Vin2 (either of the input voltages Vin1 and Vin2 may be low voltages) applied through the two input terminals IN1 and IN2, respectively. Of the two input voltages Vin1 and Vin2, the lower voltage is applied to a switching regulator section 20 on the condition that the lower voltage is not less than the reference voltage. The switching regulator section 20 is of a step-down type of regulator for generating an output voltage Vout which is lower than the voltages Vin1 and Vin2. Thus, it is preferable in conversion efficiency that the output voltage Vout is generated in accordance with the lower input voltage (of course, it is not less than the output voltage Vout). In this manner, also in the embodiment shown in Fig. 4, there is adopted a scheme wherein of the input voltages Vin1 and Vin2, the lower voltage is applied to generate the output voltage Vout, thereby implementing the efficient DC-DC conversion.

[0079] Fig. 5 is a circuit diagram of a fifth embodiment of a DC-DC converter circuit according to the present invention.

[0080] A DC-DC converter circuit 500 shown in Fig. 5 comprises the input selection circuit 210 corresponding to the second embodiment of the power supply selection circuit of the present invention shown in Fig. 2, and the switching regulator section 20 which is the same as the switching regulator section 20 shown in Fig. 20. The circuit operation of the input selection circuit 210 and the switching regulator section 20 have already been explained, and thus their explanation will be omitted here. The DC-DC converter circuit 500 shown in Fig. 5 is incorporated into an LSI chip 590, except for a coil 31 and a capacitance 32, which are part of the switching regulator section 20, similar to the fourth embodiment shown in Fig. 4.

[0081] In the input selection circuit 110, when the source is provided to both input terminals IN1 and IN2, it is always ensured that Vin1 > Vin2 is satisfied. As long as the requirement of Vin1 > Vin2 is satisfied, in the event that the input voltage Vin2 is not less than a predetermined reference voltage, the input voltage Vin2 is transmitted to the switching regulator section 20. On the other hand, in the event that the input voltage Vin2 is not more than the predetermined reference voltage, the input voltage Vin1 is transmitted to the switching regulator section 20. Therefore, in the switching regulator section 20, it is possible to perform a high efficiency DC-DC conversion.

[0082] Fig. 6 is a block diagram showing an embodiment of an apparatus according to the present invention.

[0083] An apparatus 600, for example, a personal computer, is supplied with DC power of 16.0 V generated from a commercial power supply in the external AC adapter (not illustrated), and DC power of 12 to 9 V generated from an internal battery 611, through diodes 612 and 613, respectively. The DC voltage (16.0 V) from the external AC adapter is higher than the voltage (12 to 9 V) of the battery. When the DC power is supplied from the AC adapter, the power from the battery is not supplied to the apparatus by the effect of the diode 613. On the other hand, when no power is supplied from the AC adapter, and the apparatus is operative, power is supplied from the battery 611. The power from the AC adapter or the battery 611 is fed to a DC-DC converter 614 (an example of the first DC-DC converter referred to in the present invention) and a regulator 615 (an ex-

ample of the second DC-DC converter referred to in the present invention).

[0084] The DC-DC converter 614 generates 5.0V (volts) in accordance with the input power and supplies the same to a first operating circuit 616. The first operating circuit 616 is driven by the 5.0V generated from the DC-DC converter 614. The DC-DC converter 614 receives a control signal (an on/off signal) for turning on and off the DC-DC converter, so that the DC-DC converter 614 may stop in operation for the purpose of saving power when there is no need to operate the first operating circuit 616.

[0085] The regulator 615 receives the 5.0V generated from the DC-DC converter 614 as well as power from the AC adapter or the battery 611, and generates 3.3V in accordance with lower power of the received two types of power. The 3.3V generated from the regulator 615 is supplied to a second operating circuit 617. The second operating circuit 617 is activated by the 3.3V supplied from the regulator 615. The second operating circuit 617 comprises circuits and the like which are needed to be kept operating on an interruptible power supply basis.

[0086] As the regulator 615, any one of the above-mentioned embodiments as to the DC-DC converter circuit is adopted, for example, typically, the DC-DC converter circuit shown in Fig. 2 is adopted in view of the matter that it is wired beforehand since it is incorporated into the apparatus.

[0087] When the DC-DC converter 614 is operated, and the 5.0V generated from the DC-DC converter 614 is fed to the regulator 615, the regulator 615 generates 3.3V in accordance with the 5.0V. When the DC-DC converter 614 stops the operation, the regulator 615 generates 3.3V in accordance with the 16.0V from the AC adapter or the 12 to 9V from the battery 611 when the AC adapter is not connected.

[0088] In this manner, the regulator 615 is so arranged that when the DC-DC converter 614 is operated, the 3.3V is generated from the 5.0V generated from the DC-DC converter 614. Thus, as compared with a case where regardless of the fact that the DC-DC converter is operated, the power from the AC adapter or the battery is used, it is possible to save power.

[0089] When the DC-DC converter circuit shown in Fig. 1, for example, is adopted as the regulator 615, the input and the output of the DC-DC converter 614 can be connected to either one of the two input terminals of the regulator 615. This feature makes the wiring work easy, and also may prevent such a wiring error that two types of wiring are erroneously replaced.

[0090] As mentioned above, according to the present invention, it is possible to perform a high efficiency DC-DC conversion.

[0091] While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by those embodiments but only by the appended claims. It is to be appreciated that those skilled in the art that the embodiments can be changed or modified without departing from the scope of the present invention.

Claims

1. A DC-DC converter circuit having a plurality of input terminals for connecting to a plurality of DC power supplies, and an output terminal, said DC-DC converter circuit comprising:

   a power supply selection section for selecting a DC power supply of lowest voltage on condition that the lowest voltage is not less than a predetermined voltage; and
   a step-down type of regulator section for converting the voltage of the DC power supply selected by said power supply selection section into a predetermined voltage lower than the voltage of the DC power supply selected by said power supply selection section, and outputting the converted voltage through said output terminal.

2. A DC-DC converter circuit having a first input terminal connected to a predetermined first DC power supply, and a second input terminal connected to a predetermined second DC power supply which has a voltage lower than a voltage of said first DC power supply, and an output terminal, said DC-DC converter circuit comprising:

   a power supply selection section for selecting the first DC power supply connected to said first input terminal and the second DC power supply connected to said second input terminal according to whether the voltage of the second DC power supply is less than a predetermined voltage or is not less than the predetermined voltage, respectively; and
   a step-down type of regulator section for converting the voltage of the DC power supply selected by said power supply selection section into a predetermined voltage lower than the voltage of the DC power supply selected by said power supply selection section, and outputting the converted voltage through said output terminal.

3. A DC-DC converter circuit according to claim 1 or 2, wherein said regulator section comprises a linear regulator.

4. A DC-DC converter circuit according to claim 3, wherein said power supply selection section and said regulator section comprising the linear regulator are arranged in an integrated circuit.

5. A DC-DC converter circuit according to claim 3, wherein said power supply selection circuit and portions of said regulator section comprising the linear regulator are arranged in an integrated circuit, with the exception of an output voltage control transistor which is located outside the integrated circuit.

6. A DC-DC converter circuit according to claim 1 or 2, wherein said regulator section comprises a switching regulator.

7. A DC-DC converter circuit according to claim 6, wherein said power supply selection section and portions of said regulator section comprising the switching regulator are arranged in an integrated circuit, with the exception of a voltage smoothing circuit portion which is located outside the integrated circuit.

8. A power supply selection circuit comprising:

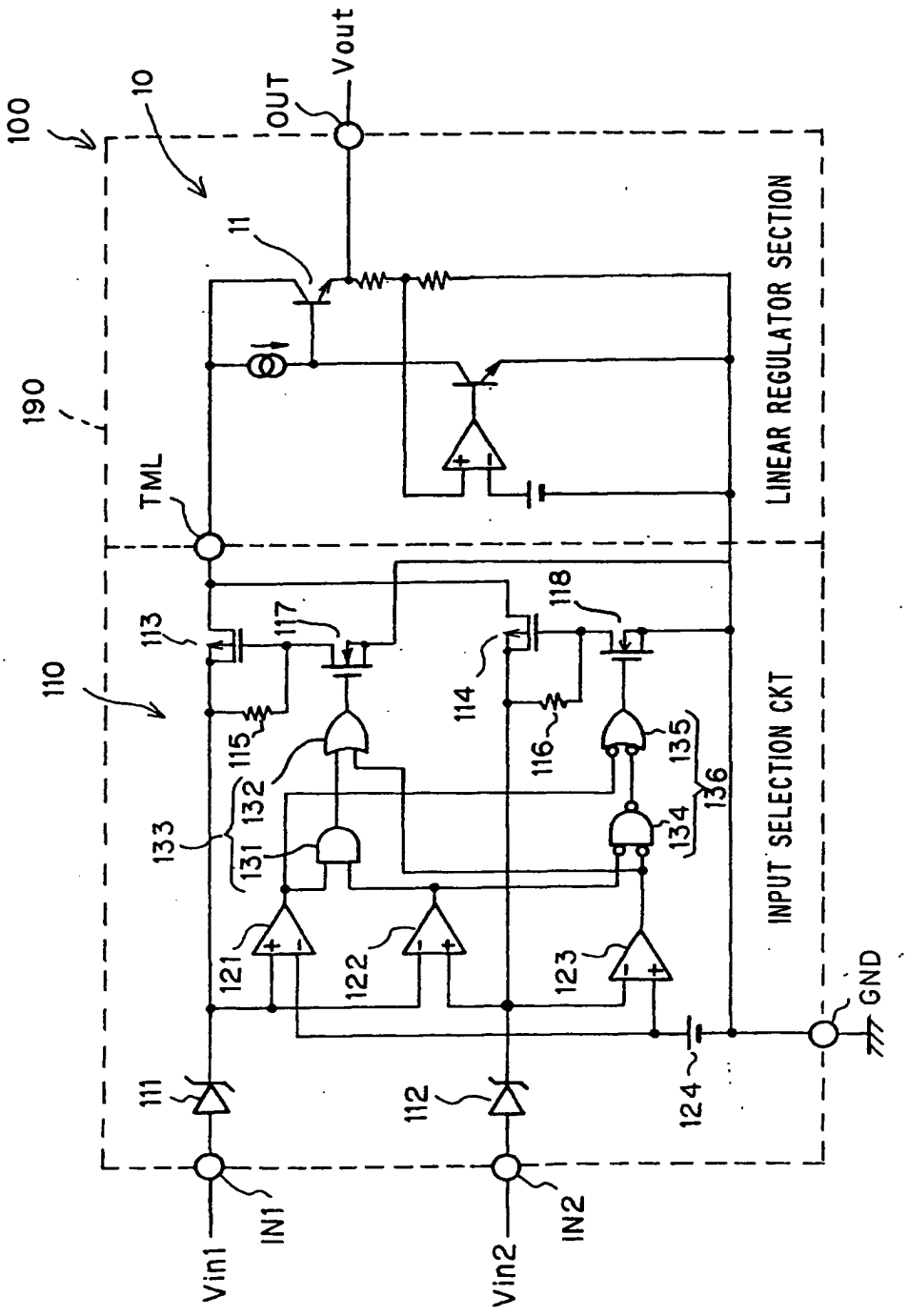
a plurality of input terminals for connecting to a plurality of DC power supplies;
a power supply selection section for selecting a DC power supply of lowest voltage, on condition that the voltage is not less than a predetermined voltage, from among the plurality of DC power supplies; and
an output terminal for outputting the voltage of the DC power supply selected by said power supply selection section.

9. A power supply selection circuit comprising:

a first input terminal connected to a predetermined first DC power supply;
a second input terminal connected to a predetermined second DC power supply which has a voltage lower than a voltage of said first DC power supply;
a power supply selection section for selecting the first DC power supply connected to said first input terminal or the second DC power supply connected to said second input terminal according to whether the voltage of the second DC power supply is less than a predetermined voltage or is not less than the predetermined voltage, respectively; and
an output terminal for outputting the voltage of the DC power supply selected by said power supply selection section.

10. A DC-DC converter having a plurality of input terminals connected to respective DC power supplies, and an output terminal, said DC-DC converter circuit comprising:

a power supply selection section for selecting the lowest-voltage DC power supply among those of said DC power supplies not less than a predetermined voltage; and
a step-down type regulator section for converting the voltage of the selected DC power supply into a lower predetermined voltage, and outputting the lower predetermined voltage through said output terminal.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Vout
11
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113
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118
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116
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132
133
131
134
INPUT SELECTION CKT
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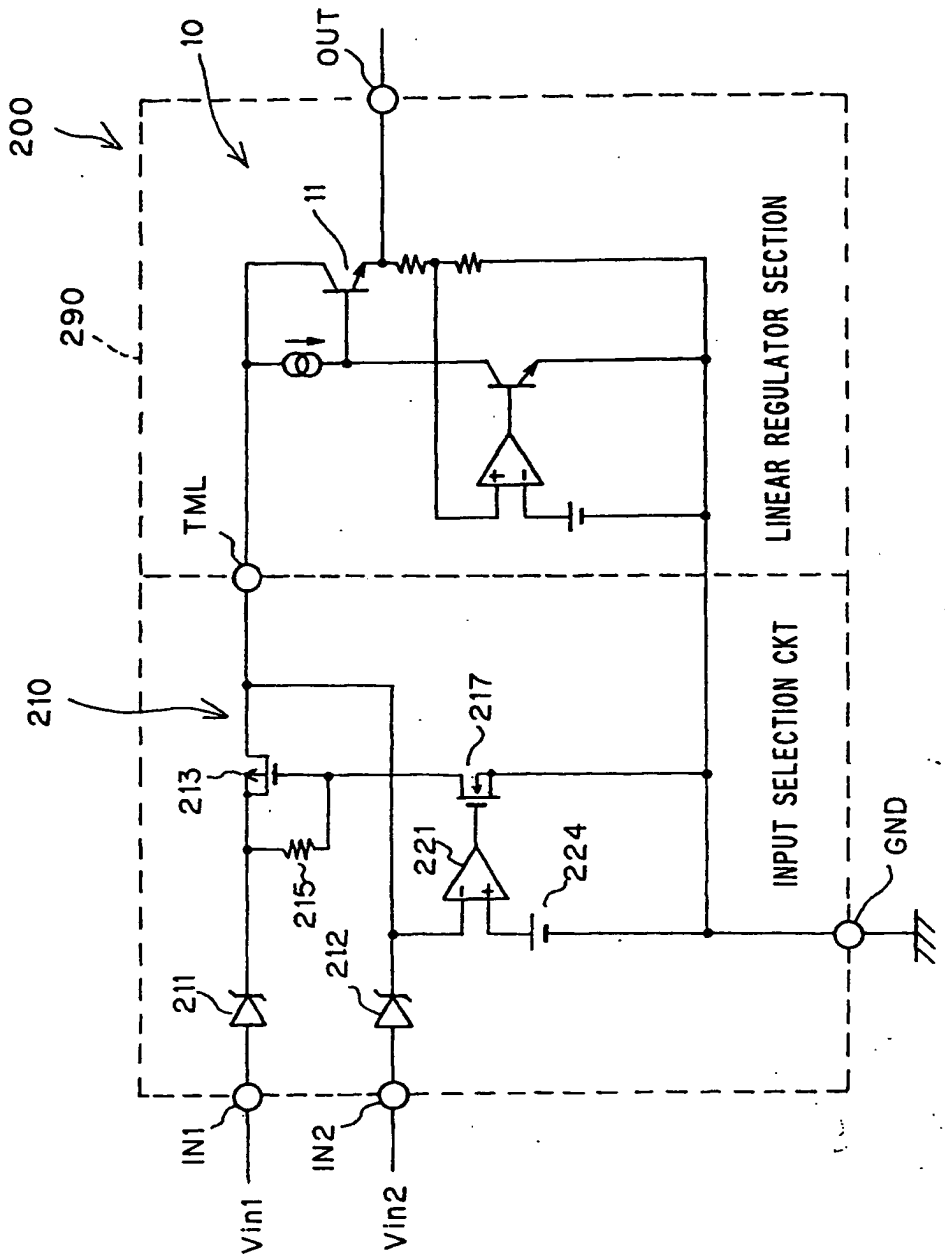
122
123
GND
124
111
112
IN1
IN2
Vin1
Vin2

Fig.1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212
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INPUT SELECTION CKT
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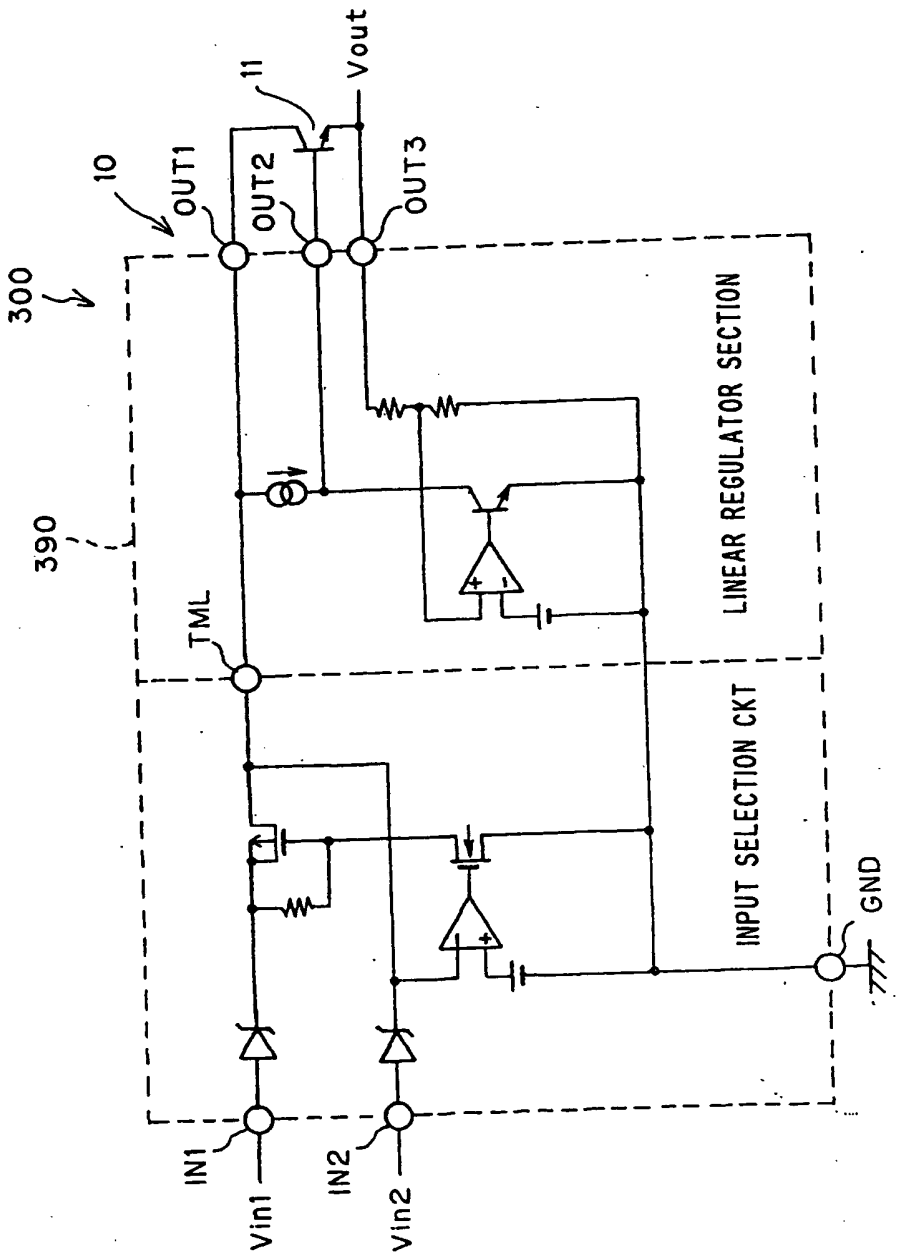
IN1
IN2
Vin1
Vin2

Fig.2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OUT3
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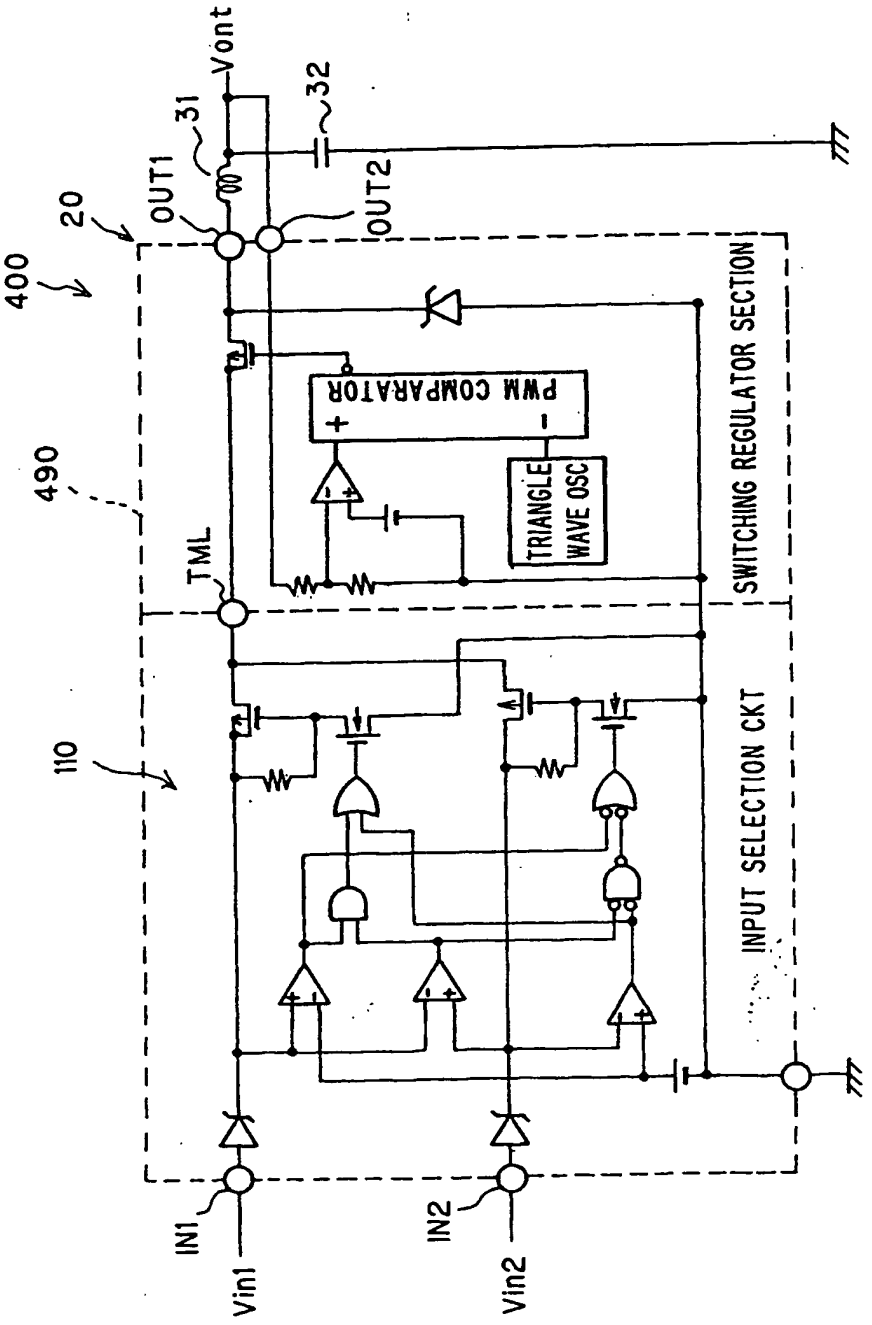
IN2
Vin1
Vin2

Fig.3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OUT2
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110
TML
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SWITCHING REGULATOR SECTION
INPUT SELECTION CKT
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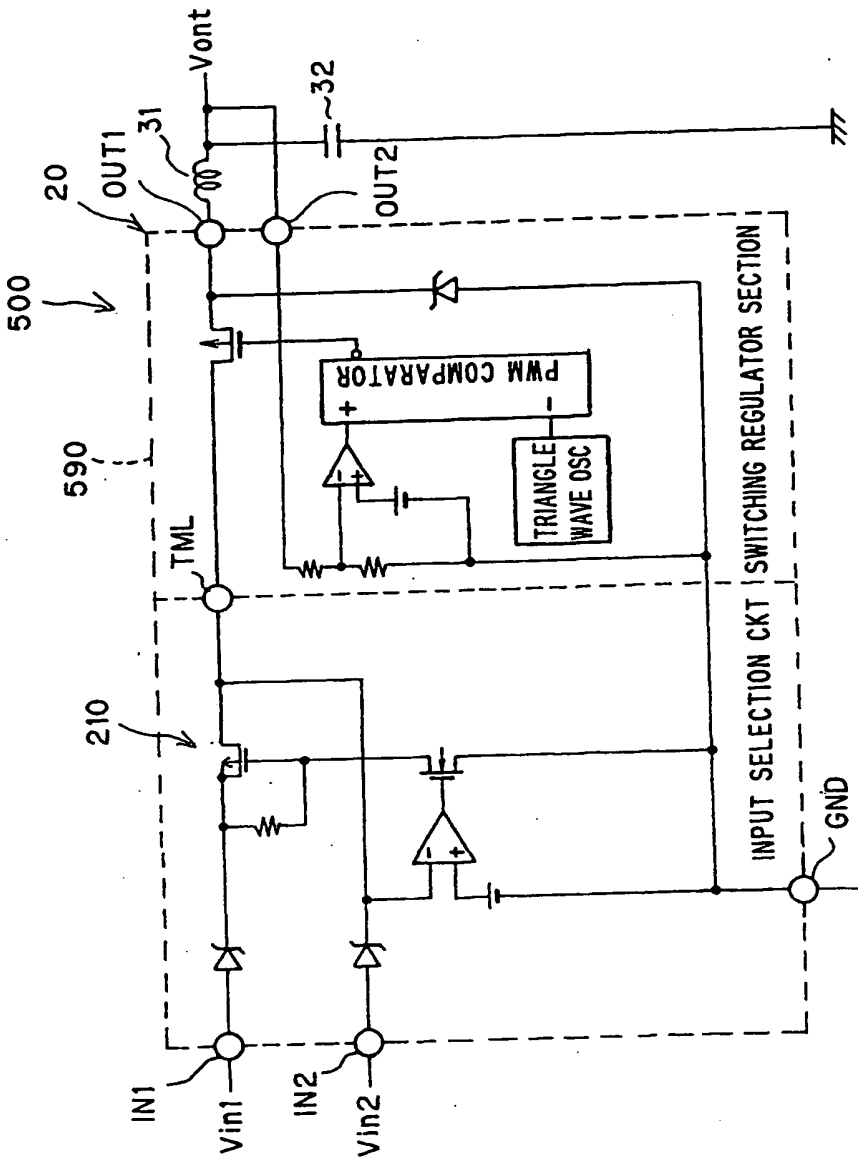
IN2
Vin1
Vin2

Fig. 4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OUT2
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TRIANGLE WAVE OSC
TML
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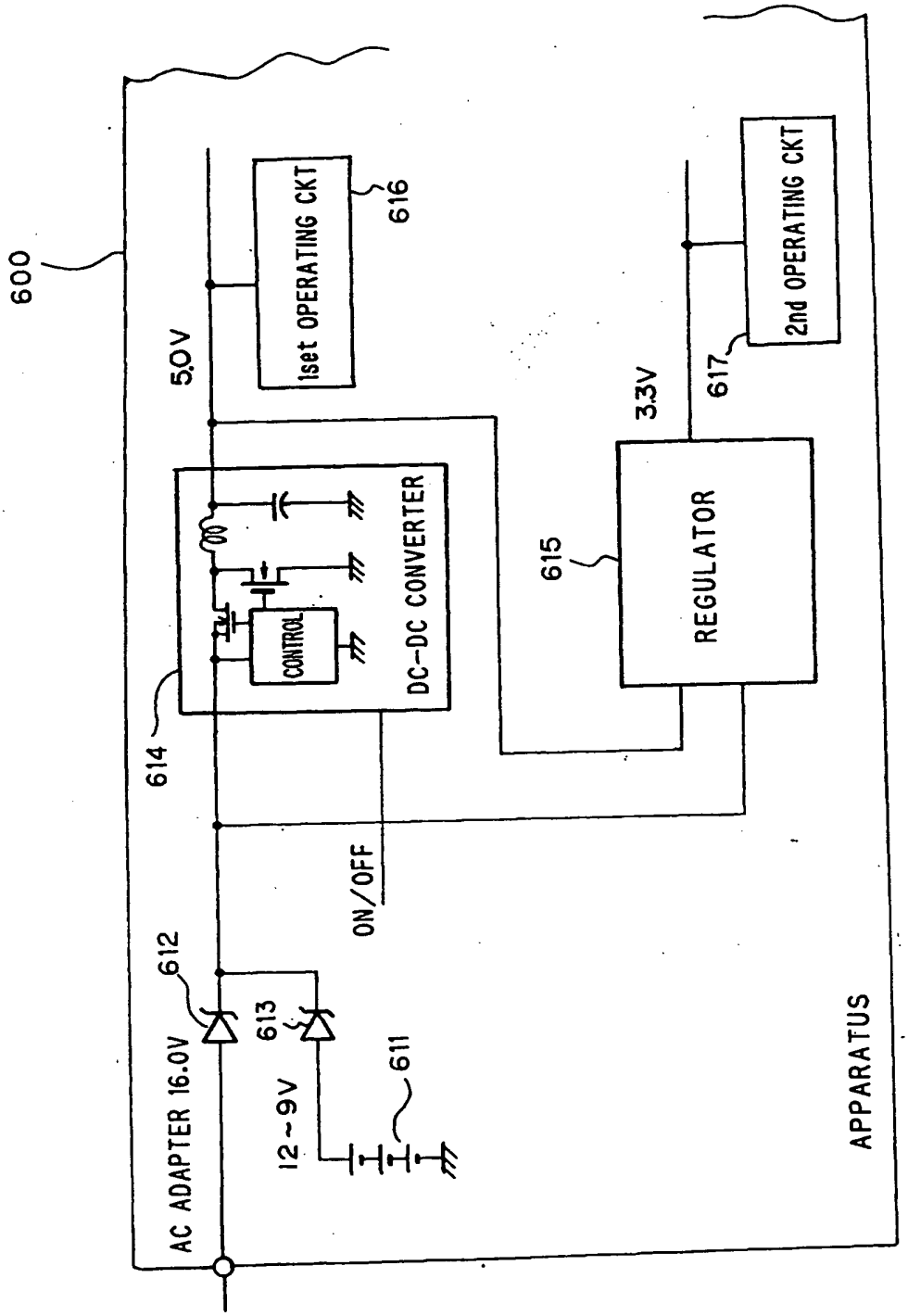
INPUT SELECTION CKT
SWITCHING REGULATOR SECTION
GND
IN1
Vin1
IN2
Vin2

Fig. 5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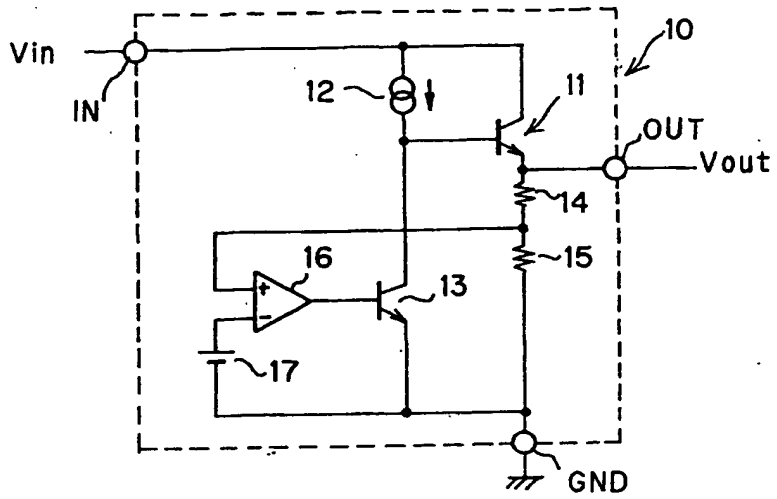
616
5.0V
2nd OPERATING CKT
617
3.3V
DC-DC CONVERTER
CONTROL
614
615
REGULATOR
ON/OFF
612
613
611
12~9V
AC ADAPTER 16.0V
APPARATUS

Fig.6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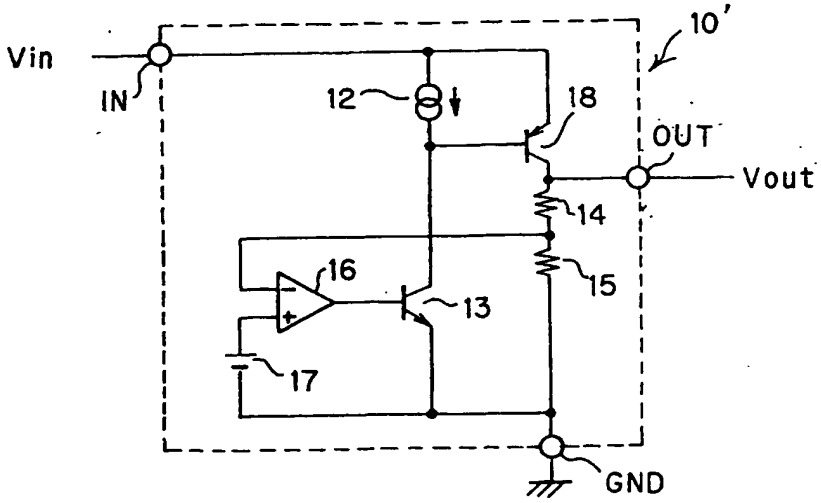
11
10
OUT
Vout
14
15
16
13
17
GND

Fig. 7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18
10'
OUT
Vout
14
15
16
13
17
GND

Fig. 8

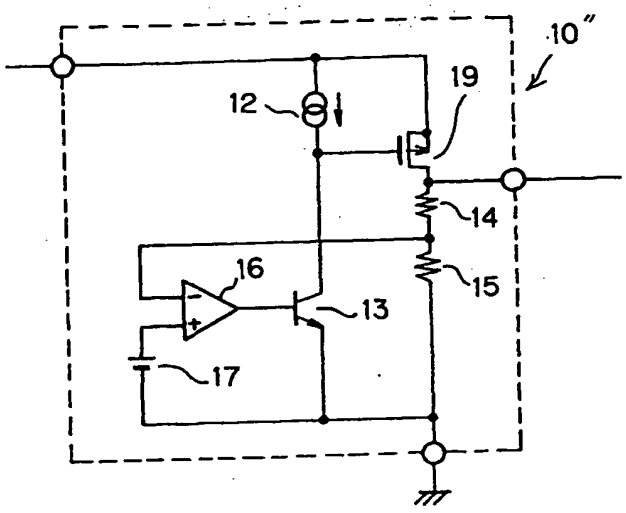
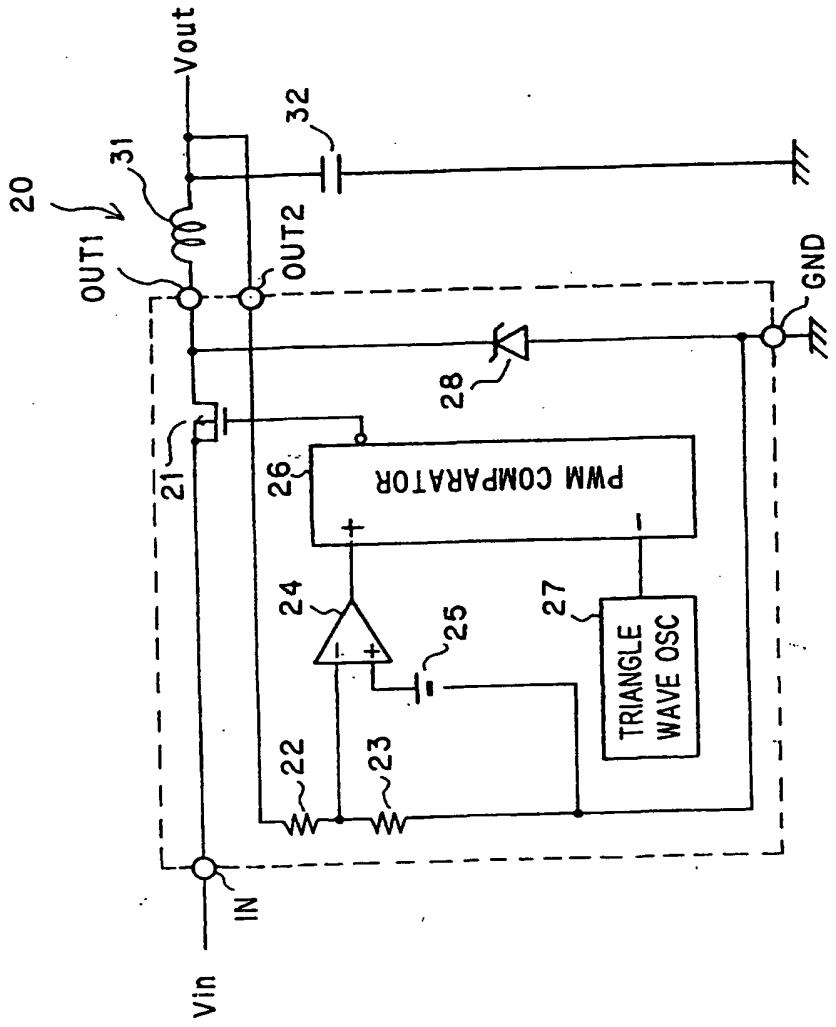


Fig.9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32
31
20
OUT1
OUT2
GND
28
21
26
PWM COMPARATOR
24
25
27
TRIANGLE WAVE OSC
22
23
IN
Vin

Fig.10